

WHAT IS CLAIMED IS:

1 1. A method for determining segment bandwidth capacity of a test segment in a
2 network, the method comprising:

3 sending a plurality of packet profiles from a plurality of source nodes to a
4 plurality of destination nodes via links, each link connecting a source node with a destination
5 node, each link including the test segment;

6 manipulating start times for sending the plurality packet profiles, or a portion
7 thereof, from the plurality of source nodes, or a portion thereof, so that the plurality of packet
8 profiles flow through the test segment essentially simultaneously; and

9 receiving the plurality of packet profiles at the plurality of destination nodes,
10 wherein each of the packet profiles comprises a plurality of packets, and byte count
11 measurements and time stamps are made at the plurality of destination nodes.

1 2. The method of claim 1, wherein a central server is utilized to command the
2 plurality of source nodes to send the plurality of packet profiles at specific times, including the
3 manipulation of the start times for the plurality of packet profiles.

1 3. The method of claim 1, wherein the network is a time synchronized network and
2 each of the plurality of packet profiles is a packet burst.

1 4. The method of claim 3, wherein the length L of each of the packet bursts is
2 related to the Degree of Desynchronization (DoD) by an expression, $L = \frac{DoD}{ErrLim}$, where ErrLim
3 represents a maximum desired error in the segment bandwidth capacity determination.

1 5. The method of claim 4, wherein the time stamps made at each of the plurality of
2 destination nodes are a first time stamp TS_{first} of the first packet of the packet burst received from
3 each corresponding source node and a last time stamp TS_{last} of the last packet of the packet burst
4 received from each corresponding source node, and the byte count measurements measure the
5 bytes $Bytes_{total}$ in each of the packet bursts received at each corresponding destination node.

1 6. The method of claim 5, wherein an individual flow rate in bit per second due to
2 each packet burst is calculated using an expression, $Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}$, and a total flow
3 rate through the test segment is the sum of all individual flow rates.

1 7. The method of claim 1, wherein the network is a non-time synchronized network
2 and each of the plurality of packet profiles is a packet stream, and a plurality of byte count
3 measurements are made over a time measurement period T at each of the plurality of destination
4 nodes.

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2 8. The method of claim 7, wherein the length $L_{multiple}$ of the packet stream is related
3 to the Degree of Desynchronization (DoD) by an expression, $L_{multiple} = (4 * T) + 2\epsilon$, where the

4 time measurement period T is one half of DoD and epsilon ε is used to compensate for small
5 timing errors.

1 9. The method of claim 8, wherein the time stamps made at each of the plurality of
2 destination nodes are a plurality of time measurements MT_n , where n is an integer, each time
3 measurements MT_n being separated by the time measurement period T and each measuring byte
4 count over the period T since last time measurement MT_{n-1} in each of the packet streams
5 received at each corresponding destination node.

1 10. The method of claim 9, wherein an individual flow rate in bit per second due to
2 each packet stream at the test segment is related to the smallest byte count measurement $Bytes_{total}$
3 of all byte count measurements taken for the packet stream, the individual flow rate being
4 calculated using an expression, $Rate(bps) = \frac{Bytes_{total} * 8}{MT_n - MT_{n-1}}$, and a total flow rate through the test
5 segment is the sum of all individual flow rates.

1 11. The method of claim 1, wherein a link bandwidth capacity of a link is determined
2 by measuring the bandwidth capacity of each of the segments that make up the link, the link
3 having a maximum throughput of the slowest segment in the link.

1 12. A method for determining bandwidth capacity of a test segment in a time
2 synchronized network, the method comprising:

3 sending a packet burst from a source node to a destination node via a link, the link
4 including at least the test segment; and
5 receiving the packet burst at destination node, the packet burst comprising a
6 plurality of packets, wherein a first time stamp TS_{first} of the first packet of the packet burst, a last
7 time stamp TS_{last} of the last packet of the packet burst and a byte count measurement measuring
8 the bytes $Bytes_{total}$ in the packet burst are made at the destination node, the bandwidth capacity of
9 the test segment in bit per second being calculated using an expression,

$$10 \quad Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}.$$

1 13. The method of claim 12, wherein the length L of the packet burst is related to the
2 Degree of Desynchronization (DoD) by an expression, $L = \frac{DoD}{ErrLim}$, where ErrLim represents a
3 maximum desired error in the bandwidth capacity determination

1 14. A method for determining bandwidth capacity of a test segment in a non-time
2 synchronized network, the method comprising:

3 sending a packet stream from a source node to a destination node via a link, the
4 link including at least the test segment, the packet stream having a length L_{single} that ensures at
5 least two measurements for byte count measurement can be made at the destination node;
6 receiving the packet stream at destination node, the packet stream comprising a
7 plurality of packets;

8 taking at least two measurements MT_{first} , MT_{second} at the destination node while
9 the packet stream is being received, the two measurements MT_{first} , MT_{second} being separated by a
10 measurement period T ; and

11 making a byte count measurement measuring the bytes $Bytes_{total}$ in the packet
12 stream between the measurements MT_{first} , MT_{second} at the destination node, the bandwidth
13 capacity of the test segment in bit per second being calculated using an expression,

$$14 \quad Rate(bps) = \frac{Bytes_{total} * 8}{MT_{second} - MT_{first}}.$$

15. The method of claim 14, wherein the length L_{single} of the packet stream is greater than or equal to $(2 * T) + 2\epsilon$, where epsilon is used to compensate for small timing error.

16. The method of claim 14, further comprising triggering the destination SN to take
a first measurement MT_{first} when it receives the first few packets in the packet stream, wherein
the length L_{single} of the packet stream is greater than or equal to $T + 2\epsilon$, where ϵ is used to
compensate for small timing error.

1 17. A network system for determining bandwidth capacity of a test segment in a
2 network, comprising:

- 3 a plurality of links interconnecting nodes residing on the edge of the network,
- 4 each of the link being made up of at least one segment;
- 5 a plurality of source nodes that send a plurality of packet profiles for traveling
- 6 through links, each link including the test segment, the plurality of packet profiles, or a portion

7 thereof, being sent at specific times so that the plurality of packet profiles flow through the test
8 segment essentially simultaneously;

9 a plurality of destination nodes that receive the plurality of packet profiles,
10 wherein each of the packet profiles comprises a plurality of packets, and byte count
11 measurements and time stamps are made at the plurality of destination nodes.

1 18. The network system of claim 17, further comprising a central server that
2 commands the plurality of source nodes to send the plurality of packet profiles at specific times,
3 including the manipulation of start times for the sending of the plurality of packet profiles, or a
4 portion thereof.

1 19. The network system of claim 17, wherein the network is a time synchronized
2 network and each of the plurality of packet profiles is a packet burst.

1 20. The network system of claim 19, wherein the length L of each of the packet bursts
2 is related to the Degree of Desynchronization (DoD) by an expression, $L = \frac{DoD}{ErrLim}$, where
3 ErrLim represents a maximum desired error in the segment bandwidth capacity determination.

1 21. The network system of claim 20, wherein the time stamps made at each of the
2 plurality of destination nodes are a first time stamp TS_{first} of the first packet of the packet burst
3 received from each corresponding source node and a last time stamp TS_{last} of the last packet of
4 the packet burst received from each corresponding source node, and the byte count

5 measurements measure the bytes $Bytes_{total}$ in each of the packet bursts received at each
6 corresponding destination node.

1 22. The network system of claim 21, wherein an individual flow rate in bit per second
2 due to each packet burst is calculated using an expression, $Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}$, and a total
3 flow rate through the test segment is the sum of all individual flow rates.

1 23. The network system of claim 17, wherein the network is a non-time synchronized
2 network and each of the plurality of packet profiles is a packet stream, and a plurality of byte
3 count measurements are made over a time measurement period T at each of the plurality of
4 destination nodes.

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2 24. The network system of claim 23, wherein the length $L_{multiple}$ of the packet stream
3 is related to the Degree of Desynchronization (DoD) by an expression, $L_{multiple} = (4 * T) + 2\epsilon$,
4 where the time measurement period T is one half of DoD and epsilon ϵ is used to compensate for
5 small timing errors.

1 25. The network system of claim 24, wherein the time stamps made at each of the
2 plurality of destination nodes are a plurality of time measurements MT_n , where n is an integer,
3 each time measurements MT_n being separated by the time measurement period T and each
4 measuring byte count over the period T since last time measurement MT_{n-1} in each of the packet
5 streams received at each corresponding destination node.

1 26. The network system of claim 25, wherein an individual flow rate in bit per second
2 due to each packet stream at the test segment is related to the smallest byte count measurement
3 Bytes_{total} of all byte count measurements taken for the packet stream, the individual flow rate
4 being calculated using an expression, $Rate(bps) = \frac{Bytes_{total} * 8}{MT_n - MT_{n-1}}$, and a total flow rate through
5 the test segment is the sum of all individual flow rates.

1 27. The network system of claim 17, wherein a link bandwidth capacity of a link is
2 determined by measuring the bandwidth capacity of each of the segments that make up the link,
3 the link having a maximum throughput of the slowest segment in the link.

1 28. The network system of claim 17, wherein the nodes are distributed at the edges of
2 the network and exist in stand-alone boxes.

1 29. The network system of claim 17, wherein the nodes are added as software
2 modules to existing end hosts or network devices.

1 30. A computer readable medium for use in conjunction with a network system
2 including a plurality of nodes for determining segment bandwidth capacity, the computer
3 readable medium including computer readable instructions encoded thereon for:
4 sending a plurality of packet profiles from a plurality of source nodes to a
5 plurality of destination nodes via links, each link connecting a source node with a destination
6 node, each link including the test segment;

7 manipulating start times for sending the plurality packet profiles, or a portion
8 thereof, from the plurality of source nodes, or a portion thereof, so that the plurality of packet
9 profiles flow through the test segment essentially simultaneously; and
10 receiving the plurality of packet profiles at the plurality of destination nodes,
11 wherein each of the packet profiles comprises a plurality of packets, and byte count
12 measurements and time stamps are made at the plurality of destination nodes.

1 31. The computer readable medium of claim 30, wherein the network is a time
2 synchronized network and each of the plurality of packet profiles is a packet burst.

1 32. The computer readable medium of claim 31, wherein the length L of each of the
2 packet bursts is related to the Degree of Desynchronization (DoD) by an expression,
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$$L = \frac{DoD}{ErrLim}$$
, where ErrLim represents a maximum desired error in the segment bandwidth
4 capacity determination.

1 33. The computer readable medium of claim 32, wherein the time stamps made at
2 each of the plurality of destination nodes are a first time stamp TS_{first} of the first packet of the
3 packet burst received from each corresponding source node and a last time stamp TS_{last} of the
4 last packet of the packet burst received from each corresponding source node, and the byte count
5 measurements measure the bytes $Bytes_{total}$ in each of the packet bursts received at each
6 corresponding destination node.

1 34. The computer readable medium of claim 33, wherein an individual flow rate in bit
2 per second due to each packet burst is calculated using an expression, $Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}$,
3 and a total flow rate through the test segment is the sum of all individual flow rates.

1 35. The computer readable medium of claim 30, wherein the network is a non-time
2 synchronized network and each of the plurality of packet profiles is a packet stream, and a
3 plurality of byte count measurements are made over a time measurement period T at each of the
4 plurality of destination nodes.

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2 36. The computer readable medium of claim 35, wherein the length $L_{multiple}$ of the
3 packet stream is related to the Degree of Desynchronization (DoD) by an expression,
4 $L_{multiple} = (4 * T) + 2\epsilon$, where the time measurement period T is one half of DoD and epsilon ϵ is
5 used to compensate for small timing errors.

1 37. The computer readable medium of claim 36, wherein the time stamps made at
2 each of the plurality of destination nodes are a plurality of time measurements MT_n , where n is
3 an integer, each time measurements MT_n being separated by the time measurement period T and
4 each measuring byte count over the period T since last time measurement MT_{n-1} in each of the
5 packet streams received at each corresponding destination node.

1 38. The computer readable medium of claim 37, wherein an individual flow rate in bit
2 per second due to each packet stream at the test segment is related to the smallest byte count

3 measurement Bytes_{total} of all byte count measurements taken for the packet stream, the individual
4 flow rate being calculated using an expression, $Rate(bps) = \frac{Bytes_{total} * 8}{MT_n - MT_{n-1}}$, and a total flow rate
5 through the test segment is the sum of all individual flow rates.

1 39. The computer readable medium of claim 30, wherein a link bandwidth capacity of
2 a link is determined by measuring the bandwidth capacity of each of the segments that make up
3 the link, the link having a maximum throughput of the slowest segment in the link.

1 40. A computer readable medium for use in conjunction with a time synchronized
2 network system including a plurality of nodes for determining segment bandwidth capacity, the
3 computer readable medium including computer readable instructions encoded thereon for:
4 sending a packet burst from a source node to a destination node via a link, the link
5 including at least the test segment; and
6 receiving the packet burst at destination node, the packet burst comprising a
7 plurality of packets, wherein a first time stamp TS_{first} of the first packet of the packet burst, a last
8 time stamp TS_{last} of the last packet of the packet burst and a byte count measurement measuring
9 the bytes Bytes_{total} in the packet burst are made at the destination node, the bandwidth capacity of
10 the test segment in bit per second being calculated using an expression,

$$11 \quad Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}.$$

1 41. The computer readable medium of claim 40, wherein the length L of the packet
2 burst is related to the Degree of Desynchronization (DoD) by an expression, $L = \frac{DoD}{ErrLim}$, where
3 ErrLim represents a maximum desired error in the bandwidth capacity determination

1 42. A computer readable medium for use in conjunction with a non-time
2 synchronized network system including a plurality of nodes for determining segment bandwidth
3 capacity, the computer readable medium including computer readable instructions encoded
4 thereon for:

5 sending a packet stream from a source node to a destination node via a link, the
6 link including at least the test segment, the packet stream having a length L_{single} that ensures at
7 least two measurements for byte count measurement can be made at the destination node,
8 receiving the packet stream at destination node, the packet stream comprising a
9 plurality of packets;

10 taking at least two measurements MT_{first} , MT_{second} at the destination node while
11 the packet stream is being received, the two measurements MT_{first} , MT_{second} being separated by a
12 measurement period T; and

13 making a byte count measurement measuring the bytes $Bytes_{total}$ in the packet
14 stream between the measurements MT_{first} , MT_{second} at the destination node, the bandwidth
15 capacity of the test segment in bit per second being calculated using an expression,

$$16 Rate(bps) = \frac{Bytes_{total} * 8}{MT_{second} - MT_{first}}.$$

1 43. The computer readable medium of claim 42, wherein the length L_{single} of the
2 packet stream is greater than or equal to $(2 * T) + 2\epsilon$, where epsilon is used to compensate for
3 small timing error.

1 44. The computer readable medium of claim 42, further comprising computer
2 readable instruction encoded thereon for triggering the destination SN to take the first
3 measurement MT_{first} when it receives the first few packets in the packet stream, wherein the
4 length L_{single} of the packet stream is greater than or equal to $T + 2\epsilon$, where epsilon is used to
5 compensate for small timing error.

1 45. The method of claim 1, wherein at least two of the plurality of packet profiles
2 from at least two of the plurality of source nodes may be sent to the same destination node.

1 46. The network system of claim 17, wherein at least two of the plurality of packet
2 from at least two of the plurality of source nodes profiles may be received by the same
3 destination node.

1 47. The computer readable medium of claim 30, wherein at least two of the plurality
2 of packet profiles from at least two of the plurality of source nodes may be sent to the same
3 destination node.